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Scope of the Claims

1. Magnetic tape—in [the context of] magnetic tape comprising a magnetic layer provided on a surface of one side of a base and a backcoating layer provided on a surface of the other side of the base—characterized in that:
   the backcoating layer is formed by dispersing within a binder microparticles discolored in an irreversible manner with an oxidation reaction and comprises minute holes of a number and size adequate for the supply of a volume of oxygen adequate for the oxidation reaction to occur.
2. The magnetic tape according to claim 1, wherein the backcoating layer is illuminated with a light beam to oxidize the microparticles, discolor the microparticles, and form a discoloration pattern of a specified shape on the backcoating layer, and servo tracking of a data track of the magnetic layer is performed using light information from the discoloration pattern thus formed.
3. The magnetic tape according to claim 1 or 2, wherein the hole rate of the minute holes in the backcoating layer is 5 to 40% by volume.
4. The magnetic tape according to any of claims 1 to 3, wherein the microparticles comprise a metal oxide with a primary particle diameter of 1 to 200 nm.
5. The magnetic tape according to any of claims 1 to 4, wherein the metal oxide comprises FeO_x ($1.34 < x < 1.5$), TiO, SnO, MnO, or Cr_2O_3.
6. The magnetic tape according to any of claims 1 to 6 [sic], wherein the arithmetic mean roughness Ra of the backcoating layer is 7 to 50 nm, and the 10 point mean roughness Rz is 40 to 250 nm.
7. The magnetic tape according to any of claims 1 to 6, wherein the backcoating layer comprises carbon black at 0.1 to 5 parts by weight per 100 parts by weight of the binder, and the carbon black has a primary particle diameter of 15 to 80 nm, a BET specific surface area of 10 to 80 m^2/g, and a DBP oil absorbance of 100 to 300 $cm^3/100g$.

8. The magnetic tape according to any of claims 1 to 7, wherein the backcoating layer comprises silicone resin particles with a primary particle diameter of 10 to 500 nm at an amount of 0.05 to 10 parts by weight per 100 parts by weight of the binder.
9 The magnetic tape according to any of claims 1 to 8, wherein the backcoating layer comprises inorganic electrically conducting microparticles with a primary particle diameter of 1 to 100 nm at an amount of 5 to 100 parts by weight per 100 parts by weight of the binder.
10. The magnetic tape according to claim 9, wherein the inorganic electrically conducting microparticles are tin oxide, antimony-doped tin oxide, indium-doped tin oxide, or indium oxide.
11. The magnetic tape according to any of claims 1 to 10, wherein the discoloration pattern comprises a single or plurality of continuous lines of a specified width.
12. The magnetic tape according to any of claims 1 to 10, wherein the discoloration pattern comprises a discontinuous line of a specified width along the lengthwise direction of the [magnetic] tape.
13. The magnetic tape according to any of claims 1 to 12, wherein reflected light of the light entering the discoloration pattern is detected to perform servo tracking.
14. The magnetic tape according to any of claims 1 to 12, wherein transmitted light of the light entering the discoloration pattern is detected to perform servo tracking.
15. The magnetic tape according to any of claims 1 to 14, wherein one or more magnetic or nonmagnetic layers are provided between the base and the magnetic layer, and acicular or spindle-shaped ferromagnetic powder with a major axis length of 0.03 to 0.2 μm or tabular ferromagnetic hexagonal ferrite powder with a diameter of 0.1 μm or less is included in the magnetic layer.

Detailed Description of the Invention
[0001]
Technical Field of the Invention
The invention relates to magnetic tape comprising an optical servo track and, more specifically, relates to magnetic tape comprising an optical servo track on a side opposite to a magnetic recording side.

[0002]

Prior Art and Problems the Invention is to Solve

In recent years, the expanding scale of personal computer networks, the importance of the security aspect of data management, and other matters have raised the demand for larger storage capacities for magnetic tape as a medium for data backup. Means for increasing capacity are methods to improve recording density and methods to extend the tape length.

[0003]

With regard to methods for extending the tape length, the length of wound tape that can be housed in a tape cartridge is the upper limit of the recording capacity, so the tape thickness must be reduced in order to bring about greater capacity. Therefore, greater capacities have limits when such methods alone are relied on. With respect to the methods for increasing recording density, it is known that the recording density of magnetic tape is lower than the recording density of a hard disk drive, and serpentine type magnetic tape in particular has a low recording density. The reason for the low recording density of serpentine type magnetic tape is the low track density. On the other hand, helical scan type magnetic tape, another recording mode, is known for having a higher track density than serpentine type magnetic tape. This is because a servo tracking system called automatic track finding (ATF) is used in helical scan type magnetic tape.

[0004]

A servo tracking system has been adopted in serpentine type magnetic tape as well as a means for improving the track density. As such a servo tracking method, a method in which servo signals are written on the same track as the data track on the magnetic recording surface (an embedded servo system) and a method in which a dedicated servo track is provided on the magnetic recording surface have been proposed. In Japanese Patent Publication No. H7-82626, a tracking system is proposed as a servo tracking system for instances in which the pitch of data tracks is several tens of microns, in which a dedicated servo track is provided on the magnetic recording surface and servo signals for tracking are read with a plurality of servo signal reproduction heads. According to this method, however, the number of servo signal reproduction heads must be increased as the number of tracks increases, and in order to avoid this, the servo track must be increased. In this manner, conventional servo tracking systems use the same area as the data area of the magnetic recording surface as the area for servo tracking, which problematically results in the reduction of the area of the data area. This problem is particularly conspicuous in the servo tracking system of Japanese Patent Publication No. H7-82626, in which there is a high track density at about 30 tpmm (tracks per mm) or greater.

[0005]
Accordingly, an object of the invention is to provide magnetic tape that can perform servo tracking without reducing the area of the data area.

Another object of the invention is to provide magnetic tape with a greater track density.

Still another object of the invention is to provide magnetic tape having a high recording capacity.

[0006]
Means for Solving the Problems
As a result of extensive investigation, the inventors found that magnetic tape that achieves the above objects can be obtained by including special microparticles on the backcoating layer and forming special holes in the magnetic tape to enable the servo track to be formed on the backcoating layer.

[0007]
Completed based on the above finding, the invention has accomplished the above objects by providing magnetic tape—in [the context of] magnetic tape in which a magnetic layer is provided on a surface of one side of a base and a backcoating layer is provided on a surface of the other side—characterized in that the backcoating layer is formed by dispersing within a binder microparticles discolored in an irreversible manner with an oxidation reaction and comprises minute holes of a number and size adequate for the supply of a volume of oxygen adequate for the oxidation reaction to occur.

[0008]
Embodiments of the Invention
Hereafter, the magnetic tape of the invention will be described with reference to the drawings based on the preferred embodiments thereof. Herein, Fig. 1 is a summary view showing the structure of a preferred embodiment of the invention, Fig. 2 is a schematic view illustrating a method for illuminating a light beam on the backcoating layer to form a discoloration pattern, and Fig. 3 is an expanded plan view of the essential parts of the backcoating layer following light-beam illumination.

[0009]
In the magnetic tape 1 of the preferred embodiment shown in Fig. 1, an intermediate layer 3 is provided on a base 2, and a magnetic layer 4 is provided as a topmost layer adjoining the intermediate layer 3. In addition, a backcoating layer 5 is provided on a surface of the other side of the base 2.

[0010]
Magnetic tape 1 shown in Fig. 1 employs a serpentine recording method, and a plurality of data tracks are formed in parallel to the running direction of the magnetic tape 1 on the magnetic layer 4. When the magnetic tape 1 is in use, a head unit comprising a specified number of magnetic heads is moved successively widthwise on the magnetic tape 1, switching among data tracks and recording and reproducing data for the data track corresponding to each magnetic head. Moreover, servo tracking is carried out so that each magnetic head may be positioned on an appropriate data track when switching among the tracks or during recording or reproduction.

[0011]
The backcoating layer 5 is formed by disbursing in a binder microparticles discolored in an irreversible manner through an oxidation reaction. In order to initiate the oxidation reaction of the microparticles, only the energy necessary for the reaction need be applied. There are no particular limits as to how the energy should be applied, but a method capable of applying energy to only a specified small region is preferably employed, and such a method is one in which a light beam such as a laser beam is illuminated.

[0012]
A method for oxidizing for microparticles by illuminating a light beam on the backcoating layer 5 will be discussed with reference to Fig. 2.

As shown in Fig. 2, laser beams 41, 41, ...are illuminated parallel to each other toward the backcoating layer 5 of the magnetic tape 1, which runs at a specified speed in the direction of Arrow A in the figure, from a plurality of laser light sources 40, 40,... arranged in parallel to the widthwise direction of the magnetic tape 1. The microparticles present at the portions that the laser beam 41 illuminates react in an oxidation reaction with oxygen present in the air and discolor. The illumination conditions of the laser beam 41 are adjusted so that discoloration takes place throughout the entire thickness of the backcoating layer 5 in the portion that the laser beam 41 illuminates. This discoloration causes a discoloration pattern 10 of a predetermined shape to form on the backcoating layer 5. The discoloration pattern in this embodiment is a pattern comprising a plurality of continuous lines having a predetermined width along the lengthwise direction of the magnetic tape 1. The width w of the discoloration pattern 10 and the degree of discoloration through the thickness of the backcoating layer 5 can be regulated by controlling the beam diameter and output of the laser beam 41. In this embodiment, the beam diameter ranges from 0.25 to 30 μm, with 1 to 25 μm being particularly preferable, and an output of 0.02 to 2 W, with 0.02 to 0.5 W being particularly preferable. Note that in Fig. 2, the discoloration pattern 10 is drawn in an emphasized manner.

[0013]
The details of the discoloration pattern formed as discussed above will be explained with reference to Fig. 3. The discoloration patterns 10, 10, ... are straight lines each having a predetermined width that are formed with equal spacing across the widthwise direction of the magnetic tape 1 and parallel along the lengthwise direction of the magnetic tape 1. In addition, these discoloration patterns 10 are formed across the entire length of the magnetic tape 1. These discoloration patterns 10 are capable of producing optical contrast, and servo tracking of the data tracks of the magnetic layer 4 can be performed using the optical information from the discoloration patterns 10. As noted above, the data tracks in the magnetic layer 4 are also formed in parallel along the lengthwise direction of the magnetic tape 1 as is the discoloration patterns 10, but there are no particular limits as to the relative spatial relationship between the data tracks and the discoloration patterns 10.

[0014]
Specific examples of the optical contrast produced by the discoloration patterns 10 are contrast generated by illuminating light of a specific wavelength at the discoloration patterns 10 and using the gradations in the intensity of the transmitted light and contrast generated by illuminating light of a specific wavelength at the discoloration patterns 10 and using the gradations in the intensity of the reflected light.

[0015]
When contrast due to gradations in transmitted light intensity is used to perform servo tracking, the intensity of transmitted light may be detected and an optical servo system, such as a push-pull method or a three-beam method, used to execute servo tracking. The procedure is similar when contrast due to gradations in reflected light intensity is used to perform servo tracking, in which case the intensity of reflected light may be detected and an optical servo system used to execute servo tracking. Optical servo systems such as a push-pull method or three-beam method are techniques generally used for servo tracking in various optical disks.

[0016]

Servo tracking in which transmitted light intensity is detected with a push-pull method will be discussed with reference to Fig. 4. As shown in Fig. 4(a), light from a light source 30, such as a semiconductor laser, which is situated in opposition to the backcoating layer 5 of a magnetic tape running perpendicular to the surface of the paper, is condensed by a lens 31 to a specific beam diameter and then enters the discoloration pattern 10 formed on the backcoating layer 5. At this time, the beam diameter is slightly smaller than the width of the discoloration pattern 10. The intensity of the light passing through the discoloration pattern 10, the base 2 (not shown), the intermediate layer 3 (not shown), and the magnetic layer 4 (not shown), or in other words, the transmitted light, is detected by a light detector 33. The detected transmitted light intensity is converted to an electrical signal and sent to a servo tracking processor 34. At the servo tracking processor 34, processing is performed with regard to the symmetry of the transmitted light beam intensity. In greater detail, if the beam intensity has left-right symmetry with respect to the centerline of the beam, the beam 35 is deemed to have entered the centerline of the discoloration pattern 10 as shown in Fig. 4(b). This state is an on-track state in which the magnetic head is properly positioned on a specified data track of the magnetic layer 4. If the beam intensity is asymmetrical either to the left or the right with regard to the centerline of the beam, the beam 35 is deemed to have deviated from the centerline to either the left or right of the discoloration pattern 10 as shown in Figs. 4(c) and (d). This state is an off-track state in which the magnetic head is not properly positioned on the specified data track of the magnetic layer. In this case, the servo tracking processor 34 issues an order to a driving device 35 of the magnetic head 36 to move the magnetic head 36 to a proper position as shown in Fig. 4(a) and, as a result, the magnetic head 36 is properly positioned by the driving device 35, or in other words, an on-track state is returned to.

[0017]
As Fig. 3 shows, the width w of the discoloration pattern 10 is preferably from 0.25 to 50 μm. When the width w is less than 0.25 μm, current optical technology is inadequate to condense the beam diameter, so malfunctions can occur when optically detecting the discoloration pattern. When the width w is greater than 50 μm, on the other hand, the formation density of the discoloration pattern 10 decreases and is not preferable if the discoloration pattern 10 is formed at multiple locations as shown in Fig. 3. As such, [the width w] is preferably kept within the above range. An even more preferable range of the width w of the discoloration pattern 10 is from 0.25 to 30 μm, and specifically from 0.8 to 25 μm. In the invention, it is preferable to use transmitted light for servo tracking, and in this case, the transmittance of the light used in servo tracking is preferably 15 to 40% of that of the entire magnetic tape (including the magnetic layer, the intermediate layer, the base, and the backcoating layer) before discoloration.

[0018]
The pitch p between neighboring discoloration patterns 10, 10 depends on the number of discoloration patterns 10 among other factors, but it is preferably equal to or greater than the width of the data tracks formed in the magnetic layer 4 and an integer factor of the width of the tracks.

[0019]
The discoloration pattern 10, as shown in Fig. 3, may be present on the specified interval along the entire width of the magnetic tape 1, may be present in plurality on only a portion of the width of the magnetic tape 10 [sic], such as a specified interval at the center portion of the widthwise direction, or may be present in plurality on a specified interval on either the left or the right side. Moreover, it may also be present on specified intervals at two or more locations on the widthwise direction of the magnetic tape 10 [sic]. For example, one or more of the patterns, which may consist of the same or different number of the patterns, may be present on the left and right sides of the magnetic tape 10 [sic], one or more of the patterns, which may consist of the same or different number of the patterns, can be arranged on the central portion and one of the left or the right side portion of the tape, or one or more of the patterns, which may consist of the same or different number of patterns, can be arranged on the central portion and the left and the right side portions of the tape. And in any case, the total number of the discoloration patterns 10 is preferably the reciprocal of the integer number of the data tracks on the magnetic layer 4.

[0020]

The backcoating layer 5 comprises minute holes of a number and size adequate to provide a volume of oxygen adequate for the oxidation reaction of the microparticles to occur. Thereby, oxygen is supplied through the entire thickness of the backcoating layer 5 through the minute holes, and the oxidation reaction of the above microparticles can adequately proceed. As a result, the discoloration pattern 10 can produce an adequate optical contrast. The state of the minute holes may be either an open state exposed to the front surface of the backcoating layer 5 or a closed state present in the inside of the backcoating layer 5 and not exposed to the surface thereof. However, a highly large number of minute holes in the closed state causes a relative decrease in the amount per unit volume of the microparticles and other powders and the binders, sometimes making the contrast of the discoloration pattern inadequate or the film strength of the backcoating layer 5 inadequate. Therefore, the minute holes are preferably in an open state or mostly in an open state. Nevertheless, there is no problem if the minute holes are present in a closed state, provided that the discoloration pattern contrast and the film strength of the backcoating layer 5 are of an adequate level.

[0021]
In order to form the minute holes in the backcoating layer 5, the weight ratio of the total weight of the various powders, discussed later, to the total weight of the resin component that includes the binder and as well as [sic] a hardening agent of the components making up the backcoating layer (hereinafter referred to as the "P:B ratio") should be controlled. Preferable P:B ratios are 100:10 (= 10) to 100:30 (= 3.33) and especially 100:14 (= 7.14) to 100:25 (= 4). Making the P:B ratio in the backcoating layer 5 within this range allows the minute holes to be formed with a hole diameter of preferably 1 to 20 nm and particularly 2 to 15 nm as well as a hole rate (the percentage volume the minute holes occupy in the volume of the backcoating layer 5) is preferably 5 to 40% and particularly 10 to 35%.

[0022]
The measurement of the hole diameter and hole rate of the minute holes can be done according to the following method through nitrogen gas adsorption.

Belsorp 36, a high-precision totally automatic gas adsorption device by Japan Bell was the measuring device used.

Approximately 100 cm^2 of magnetic tape having only the backcoating layer remaining on the base (i.e., magnetic tape with the magnetic layer 4 and the intermediate layer 3 removed) was taken and used as the measurement sample. The sample was sealed in a test tube, nitrogen gas with the purity of 99.9999% was used as the adsorption gas, and helium with the purity of 99.9 999% was used as the carrier gas.

As a pretreatment to measurement, this was left alone for one hour at room temperature (at an ultimate vacuum of 0.2 to 0.4 Pa) and then measured at an adsorption temperature of 77 K. The measurement mode was set at isothermal adsorption and release mode, the measurement range was a relative pressure (P/P_0) of 0.00 to 0.99, and the equilibrium time was 300 s per relative pressure.

The distribution of the whole diameters measured was calculated and smoothed using the DH method (Dollimore and Heal method). International standard sample NPL (National Physical Laboratory) graphite carbon (rated at 11.1 m^2, $\delta = 0.8$ m^2/g) was measured in advance of the measurement of the above sample to confirm measurement precision to be within 2% and accuracy to be within 5%. There were no fine holes present in the base.

In this Specification, "hole diameter" refers to the hole diameter at which a peak (the highest frequency on the distribution curve) is noted on the distribution curve obtained through the measurement of hole diameter as above.

[0023]
Hole rate (%) is obtained by dividing the total volume of minute holes calculated with the DH method by the measured volume of the backcoating layer (the product of thickness and area) and multiplying by 100.

[0024]
Next, the microparticles will be discussed in detail.

There are no particular limits on the substance used as the microparticles provided that it is irreversibly discolored by the oxidation reaction, and a metal oxide is preferably used given the particular ease of discoloration and high color contrast before and after discoloration of such substances. Examples are FeO_x ($1.34 < x < 1.5$), TiO, SnO, MnO, and Cr_2O_3. It is particularly preferable to use FeO_x, given its discoloration characteristics.

[0025]
FeO_x is a magnetite-type iron oxide that includes divalent and trivalent iron, and divalent iron therein preferably constitutes 5 to 24% by weight of the total FeO_x and particularly 10 to 20% by weight.

[0026]
From the standpoint of surface smoothness of the backcoating layer, the primary particle diameter of the microparticles is preferably 1 to 200 nm and particularly 5 to 80 nm. And microparticles, in terms of the P:B ratio discussed above, preferably are present at 300 to 1200 parts by weight and particularly 350 to 1000 parts by weight to 100 parts by weight of the binder. In greater detail, if the composition by weight of the microparticles is less than 300 parts by weight, their sensitivity to discoloration is inadequate and an adequate optical contrast can sometimes not be attained, while at over 1200 parts by weight, the strength of the applied [microparticle] film of the backcoating layer can fall, so it is preferably with in this range.

[0027]
As the binder, any substance usable in magnetic tape can be used without limit. Examples are thermoplastic resins, thermosetting resins, reactive resins, and mixtures thereof. Specifically, vinyl chloride copolymers or modifications thereof, copolymers comprising acrylic acid, methacrylic acid, or esters thereof, acrylonitrile copolymers (rubber-like resins), polyester resins, polyurethane resins, epoxy resins, cellulosic resins, and polyamide resins can be used. The number average molecular weight of the binder is preferably 2,000 to 200,000. In order to improve the dispersing properties of various particles included in the backcoating layer 5, the binder can include a polarizing functional group (so-called polar group) such as a hydroxyl group, a carboxyl group or a salt thereof, a sulfo group or a salt thereof, a phosphate group or a salt thereof, a nitro group, a nitric ester group, an acetyl group, a sulfuric ester group or a salt thereof, an epoxy group, a nitrile group, a carbonyl group, an amino group, an alkylamino group, an alkylammonium salt group, a sulfobetaine structure, a carbobetaine structure, or another betaine structure. The binder is preferably used in an amount of 10 to 50 parts by weight, particularly 12 to 30 parts by weight, per 100 parts by weight of the magnetic powder.

[0028]
The backcoating layer 5 of the magnetic tape 1 is also used for the formation of a discoloration pattern used in servo tracking as described above but of course must have functions characteristic of a backcoating layer. Examples of such functions are (1) the provision of satisfactory running characteristics to the magnetic tape, (2) the provision of electrostatic prevention for the magnetic tape, and (3) the detection of the beginning of the tape (BOT) and the end of the tape (EOT).

[0029]
To bring about function (1) above, the backcoating layer preferably has an appropriate surface roughness. On the other hand, the backcoating layer is preferably as smooth as possible so that the surface shape of the backcoating layer is not transferred to the magnetic layer during tape winding. In consideration of the balance between these two, the arithmetic mean roughness Ra of the backcoating layer 5 is preferably from 7 to 50 nm and particularly from 8 to 30 nm, and the 10 point mean roughness Rz is preferably 40 to 200 nm, particularly 80 to 150 nm.

[0030]
The arithmetic mean roughness Ra is computed with a sensing pin surface roughness meter—it was measured under the following conditions in accordance with JIS-B0601-1994. Ra is defined with Equation (i) below.

- Needle diameter: 1.5–2.5 μm; curvature: 60°
- Needle pressure: 50–300 μN
- Cutoff: 80 μm
- Standard length: 80 μm
- Measured length: 400 μm

[0031]
[Equation 1]

$$Ra = \frac{1}{\ell} \int_0^{\ell} |Y(x)|\, dx \qquad (i)$$

where Y indicates profile data and *l* indicates the measured length.

[0032]
The specimen to be measured is placed on a microscope slide with properties that fulfill JIS-R-3502 (in this Specification, a slide made by Matsunami Glass was used, but the slide is not limited thereto), attached with water or ethanol, and measured. At this time, an excess of water or ethanol will prevent results of good reproducibility, so the measurement taken after a certain amount of water or ethanol has evaporated and during the time interference fringe is seen from beneath the slide is taken as Ra.

[0033]
The 10 point mean roughness Rz was determined with Equation (ii) in accordance with JIS-B0601-1994 under conditions similar to those for Ra. The standard length l was 80 μm and the assessment length l_0 was 400 μm.

[0034]
[Equation 2]

$$Rz = \frac{|Y_{p1}+Y_{p2}+Y_{p3}+Y_{p4}+Y_{p5}|+|Y_{v1}+Y_{v2}+Y_{v3}+Y_{v4}+Y_{v5}|}{5} \quad \text{(ii)}$$

where Y_{p1}, Y_{p2}, Y_{p3}, Y_{p4}, and Y_{p5} represent the standard height of the first to the fifth highest peaks in the cutout portion corresponding to the standard length *l*, and Y_{v1}, Y_{v2}, Y_{v3}, Y_{v4}, and Y_{v5} represent the standard height of the first to the fifth lowest valleys in the cutout portion corresponding to the standard length *l*.

[0035]
So that the arithmetic mean roughness Ra and the 10 point mean roughness Rz of the backcoating layer 5 are within the above range, carbon black having a primary particle diameter of 15 to 80 nm, a BET specific surface area of 10 to 80 m^2/g, and a DBP oil absorbance of 100 to 300 $cm^3/100$ g is preferably included in the backcoating layer 5. The carbon black more preferably has a primary particle diameter of 25 to 80 nm, a BET specific surface area from 15 to 70 [unit missing], and a DBP oil absorbance of 120 to 250 $cm^3/100$ g.

[0036]
The carbon black is preferably added at 0.1 to 5 and particularly 0.1 to 3 parts by weight to 100 parts by weight of the binder so that a P:B ratio within the above preferable range is attained and the arithmetic mean roughness Ra and the 10 point mean roughness Rz of the backcoating layer 5 are within the above preferable range.

[0037]
Carbon black is known for its strong light-blocking properties. Therefore, when transmitted light is to be used for servo tracking, the inclusion of a large amount of carbon black in the backcoating layer 5 could increase light shielding and prevent an adequate amount of light from passing through. As such, silicone resin particles with a primary particle diameter smaller than the thickness of the backcoating layer 5 are preferably included in the backcoating layer 5 instead of or together with carbon black to bring about function (1) above. The preferable range of the primary particle diameter of the silicone resin particles is 10 to 500 nm and particularly 10 to 300 nm. An alkyl-modified silicone resin (resin particles in which siloxane bonds have a web-like structure extending in three dimensions within the resin whose terminals (the particle surface)is alkyl-modified) is appropriately used as the silicone resin particles. Regardless of whether the above silicone resin particles are to be used with or without the carbon black, they are preferably included at 0.05 to 10 and particularly from 0.1 to 5 parts by weight to 100 parts by weight of the binder so that a P:B ratio within the above preferable range is attained and the arithmetic mean roughness Ra and the 10 point mean roughness Rz of the backcoating layer 5 are within the above preferable range.

[0038]
In order to bring about function (2) above, it is preferable to add an electrically conducting substance to the backcoating layer. Carbon black is a representative example of such a substance. But as was stated, carbon black has strong light-blocking properties, so when transmitted light is to be used for servo tracking, the inclusion of a large amount of carbon black in the backcoating layer 5 could increase light shielding and prevent an adequate amount of light from passing through. As such, inorganic electrically conducting microparticles are preferably included in the backcoating layer 5 instead of or together with carbon black to bring about function (2) above. Examples of substances used as the inorganic electrically conducting microparticles are tin oxide, titanium dioxide, zinc oxide, indium oxide, zinc sulfide, barium sulfide, silicone oxide, and magnesium carbonate, which are listed on lines 42 to 45 of the third column in Japanese Unexamined Patent Application Publication H6-236541. Such inorganic electrically conducting microparticles are generally white and transmit light well, which makes the use of such inorganic electrically conducting microparticles advantageous when transmitted light is used for servo tracking. Particularly preferable inorganic electrically conducting microparticles are [those comprising] tin oxide, antimony-doped tin oxide (ATO), indium-doped tin oxide (ITO), or indium oxide. The primary particle diameter of the inorganic electrically conducting microparticles is preferably 1 to 100 nm, particularly 2 to 100 nm, and especially 5 to 50 nm. Regardless of whether the inorganic electrically conducting microparticles are to be used with or without the carbon black, they are preferably included at 5 to 100 and particularly from 10 to 80 parts by weight to 100 parts by weight of the above microparticles so that a P:B ratio within the above preferable range is attained and function (2) is adequately expressed.

[0039]
With regard to function (3), the function can be substituted with the discoloration pattern 10 in the magnetic tape of the invention. Conventionally, a light-transmitting method was used in the detection of EOT and BOT, so carbon black had to be included in the backcoating layer 5, but as a result of the above, the inclusion of carbon black for the detection of EOT and BOT is unnecessary in the invention. This is very advantageous when, as discussed above, transmitted light is used in servo tracking.

[0040]
A lubricant and a hardener may also be included in the backcoating layer 5 in addition to the above components.

[0041]
The lubricants that can be generally used include fatty acids and fatty acid esters.

Examples of the fatty acids are caproic acid, caprylic acid, capric acid, lauric acid, myristic acid, palmitic acid, stearic acid, isostearic acid, linolenic acid, oleic acid, elaidic acid, behenic acid, malonic acid, succinic acid, maleic acid, glutaric acid, adipic acid, pimelic acid, azelaic acid, sebacic acid, 1,12-dodecanedicarboxylic acid, and octanedicarboxylic acid.

Examples of the fatty acid esters are alkyl esters of the above fatty acids, with those having a total number of carbon atoms from 16 to 46 carbon atoms being preferable.

An inorganic ester salt such as a phosphate ester can also be used.

These lubricants are preferably added in an amount of 0.05 to 15 parts by weight and particularly 0.2 to 10 parts by weight per 100 parts by weight of the binder.

[0042]
The hardeners that are generally used include isocyanate hardeners, exemplified by Coronate L (a product name) produced by Nippon Polyurethane Industry Co., Ltd. and amine hardeners. The hardener is added in an amount of 5 to 30 parts by weight and preferably 5 to 20 parts by weight per 100 parts by weight of the binder.

[0043]
The backcoating layer 5 is formed by applying a backcoating composition having the above components dispersed in a solvent to the base 2. Examples of the solvent are ketone solvents, ester solvents, ether solvents, aromatic hydrocarbon solvents, and chlorinated hydrocarbon solvents. The solvent is preferably added so that the solid component of the backcoating agent constitutes 10 to 50% by weight and particularly 20 to 40% by weight.

[0044]
The thickness of the backcoating layer 5, which is formed by applying the above backcoating composition, is preferably 0.1 to 1.5 μm and particularly 0.2 to 0.8 μm in consideration of the balance between the transparency of the discoloration pattern 10 and the thickness of the magnetic layer 4.

[0045]
The plurality of the discoloration patterns 10, 10, ... along the lengthwise direction of the magnetic tape 1 is formed in the backcoating layer 5 shown in Fig. 3, but instead of such discoloration patterns, a single, straight-line, continuous discoloration pattern along the lengthwise direction of the magnetic tape 1 could be formed on the backcoating layer 5. Alternatively, a single or plurality of sine-wave-shaped, continuous discoloration patterns along the lengthwise direction of the magnetic tape 1 could also be formed in the backcoating layer 5. And as shown in Fig. 5, a discontinuous discoloration pattern 10 along the lengthwise direction of the magnetic tape 1 could also be formed in the backcoating layer 5.

[0046]

To provide an explanation of the discoloration pattern 10, shown in Fig. 5, the discoloration pattern 10 comprises a discoloration pattern 10a slanted at angle θ° relative to the lengthwise direction of the magnetic tape 1 and a discoloration pattern 10b slanted at angle $-\theta^{\circ}$ that are perpendicular along the lengthwise direction of the magnetic tape 1 and symmetrical relative to the centerline c along the lengthwise direction of the magnetic tape. The value of angle θ is influenced by the accuracy of positioning in servo tracking, so in order to secure an adequate accuracy, the value of angle θ is preferably 5 to 85° and particularly 10 to 30°. The lengths of the discoloration pattern 10a and the discoloration pattern 10b can be different, but they are preferably the same, and are preferably each 5 to 140 mm and particularly 5 to 80 mm. The gap g between the discoloration pattern 10a and the discoloration pattern 10b with regard to the lengthwise direction of the magnetic tape 1 should be as small as possible. And even if the discoloration pattern 10 shown in Fig. 5 is used, servo tracking can be performed similarly to that when the discoloration pattern 10 shown in Fig. 3 is used.

[0047]
Next, the general items of the magnetic tape of the invention will be described.

[0048]
The magnetic layer 4 of the magnetic tape 1 shown in Fig. 1 is formed by applying a magnetic coating material comprising ferromagnetic powder and a binder. In other words, the magnetic tape 1 is coated magnetic tape.

[0049]
Examples of ferromagnetic powders that can be used are acicular or spindle-shaped ferromagnetic powder and tabular ferromagnetic powder. Acicular or spindle-shaped ferromagnetic powder includes ferromagnetic metal powder consisting primarily of iron as well as ferromagnetic iron oxide powder. An example of tabular ferromagnetic powder is ferromagnetic hexagonal ferrite powder.

[0050]
In greater detail, the ferromagnetic metal powder includes powder having a metal content of 50% by weight or more, 50% by weight or more of the metal content being iron. Specific examples of such ferromagnetic metal powders include Fe-Co, Fe-Ni, Fe-Al, Fe-Ni-Al, Fe-Co-Ni, Fe-Ni-Al-Zn, and Fe-Al-Si. The ferromagnetic iron oxide powder includes γ-Fe_2O_3, Co-containing γ-Fe_2O_3, and Co-doped γ-Fe_2O_x ($4/3 \leq x < 1.5$). The acicular or spindle-shaped ferromagnetic powder preferably has a major axis length of 0.03 to 0.2 μm and particularly 0.05 to 0.16 μm, with an acicular ratio (i.e., major axis length to minor axis length) of 3 to 15 and particularly 3 to 10. The coercive force (Hc) thereof is preferably 125 to 200 kA/m and particularly 135 to 190 kA/m, and the saturation magnetization (σs) is preferably 119 to 167 Am^2/kg and particularly 127 to 152 Am^2/kg. The BET specific surface area of the acicular ferromagnetic powder is preferably 30 to 70 m^2/g and particularly 40 to 70 m^2/g.

[0051]
The ferromagnetic hexagonal ferrite powder includes minute tabular magnetic particles of barium ferrite, strontium ferrite, or those substances with part of the Fe atoms replaced with Ti, Co, Ni, Zn, V or similar atoms. The ferromagnetic hexagonal ferrite powder preferably has a tabular diameter of 0.1 μm or less, particularly 10 to 90 nm, and especially 10 to 40 nm. The tabular ratio (tabular diameter to tabular thickness) is preferably 2 to 7 and particularly 2 to 5. The coercive force (Hc) thereof is preferably 135 to 260 kA/m, and the saturation magnetization (σs) is preferably 27 to 72 Am^2/kg and particularly 43 to 72 Am^2/kg. Moreover, the BET specific surface area of the ferromagnetic hexagonal ferrite powder is preferably 30 to 70 m^2/g.

[0052]
If necessary, the ferromagnetic powder can contain rare earth elements or transition metal elements. Moreover, surface treatment can be performed on the ferromagnetic powder to improve dispersibility and similar properties. Examples of such surface treatment are a method in which the surface of the ferromagnetic particles is coated with an inorganic oxide and a similar method. Examples of inorganic oxides that can be used in such a case are Al_2O_3, SiO_2, TiO_2, ZrO_2, SnO_2, Sb_2O_3, and ZnO, and these inorganic oxides can be used either individually or as a mixture of two or more. Other than the above method, the surface treatment can also be performed by an organic treatment, such as a silane coupling treatment, a titanium coupling treatment, or an aluminum coupling treatment.

[0053]
A substance similar to that presented as an example of the binder used to form the backcoating layer 5 can be used as the above binder. Therefore, the details of this binder will not be discussed in particular, but the explanation detailing the backcoating layer 5 is applicable as appropriate. The binder is preferably added at 10 to 40 parts by weight and particularly 15 to 25 parts by weight per 100 parts by weight of the ferromagnetic powder.

[0054]
The magnetic layer 4, in addition to the components noted above, can contain abrasive particles, carbon black, a lubricant, a hardener, or another such substance.

[0055]
A powder of a substance having a Mohs hardness of 7 or higher, such as alumina, silica, ZrO_2, or Cr_2O_3, is preferably used as the abrasive particles. From the standpoint of reduction in the frictional coefficient during running and better running durability, the primary particle diameter of the abrasive particles is preferably 0.03 to 0.6 μm and more preferably 0.05 to 0.3 μm. The abrasive particles are preferably added in an amount of 2 to 20 parts by weight and particularly 3 to 15 parts by weight per 100 parts by weight of the ferromagnetic powder.

[0056]
Substances similar to those used to form of the backcoating layer 5 can be used as the above carbon black, lubricant, and hardener. Therefore, the details of these components will not be discussed in particular, but the explanation detailing the backcoating layer 5 [should be] appropriately applied. The carbon black is preferably added in an amount of 0.1 to 10 parts by weight and particularly 0.1 to 5 parts by weight per 100 parts by weight of the ferromagnetic powder. The lubricant is preferably added in an amount of 0.5 to 10 parts by weight and particularly 0.5 to 5 parts by weight per 100 parts by weight of the ferromagnetic powder. The hardener is preferably added in an amount of 2 to 30 parts by weight and particularly 5 to 20 parts by weight per 100 parts by weight of the ferromagnetic powder.

[0057]
As required, various additives normally used in magnetic tape, such as dispersants, rust inhibitors, and antifungals, can be added to the magnetic layer 4 in addition to the above-described components.

[0058]
The magnetic layer 4 is formed by applying on an intermediate layer 3 a magnetic coating composition with the above components dispersed in a solvent. A solution similar to those described as an example of the solvents used for the backcoating solution can be used as the solvent. The amount of solvent in the magnetic coating composition is preferably 80 to 500 parts by weight and particularly 100 to 350 parts by weight per 100 parts by weight of the ferromagnetic powder included in the magnetic coating composition.

[0059]
To prepare the magnetic coating composition, the ferromagnetic powder and the binder are preliminarily mixed together with a portion of the solvent in a Naughter mixer, etc. to obtain a mixture, the mixture is kneaded in a continuous pressure kneader, a twin-screw kneader, or a similar machine., [the mixture] is diluted with a portion of the solvent and dispersed with a sand mill or similar implement, the lubricant or another additive is added, filtering is performed, and the remainder of the solvent and the hardener are added, for example.

[0060]
From the standpoint of contributing to adequate recording and playback characteristics, the coercive force of the magnetic layer formed from the magnetic coating composition is preferably 119 to 280 kA/m, more preferably 120 to 250 kA/m, and even more preferably 125 to 222 kA/m. The saturation magnetic flux of the magnetic layer 4 is preferably 0.1 to 0.5 T and particularly 0.15 to 0.45 T.

[0061]
From the standpoint of a better S/N and for preventing self-demagnetization, the thickness of the magnetic layer 3 [sic] is preferably 0.05 to 3 μm and more preferably 0.1 to 0.8 m [sic].

[0062]
Next, the intermediate layer 3 is discussed.

The intermediate layer 3 may be either a layer having magnetism or a nonmagnetic layer. When the intermediate layer 3 is a layer having magnetism, the intermediate layer 3 is a magnetic layer containing magnetic powder and is formed by using a magnetic coating material primarily comprising magnetic powder, nonmagnetic powder, a binder, and a solvent. When, on the other hand, the intermediate layer 3 is a nonmagnetic layer, the intermediate layer 5 [sic] is formed by using a nonmagnetic coating material primarily comprising nonmagnetic powder, a binder, and a solvent. (These coating materials will be generally referred to as an "intermediate layer coating material.")

[0063]
Ferromagnetic powder is preferably used as the magnetic powder. Both hard magnetic powder and soft magnetic powder are used preferably as the ferromagnetic powder.

[0064]
The hard magnetic powder can be, for example, the ferromagnetic hexagonal ferrite powder, ferromagnetic metal powder, and ferromagnetic iron oxide powder used in the magnetic layer 4. Details regarding these magnetic powders will not be discussed because they are similar to the ferromagnetic powders used in the magnetic layer 4, but a discussion regarding the strong magnetic powder is appropriately applied.

[0065]
While there are no particular limits with regard to the soft magnetic powder, a substance generally used in so-called low-current devices, such as a magnetic head or electronic circuit, is preferred, and, for example, the soft magnetic materials described in *Chikazumi Toshinobu, Kyojiseitai no Butsuri (2nd Vol.) Jikitokusei to Ohyo*, pp. 368–376, Shokabo (1984) can be used. Specifically, soft magnetic oxide powder and soft magnetic metal powder can be used—specifically, soft magnetic oxide powder and soft magnetic metal powder can be used.

[0066]
Spinel type ferrite powder is preferably used as the soft magnetic oxide powder. The spinel type ferrite powder includes $MnFe_2O_4$, Fe_3O4, $CoFe_2O_4$, $NiFe_2O_4$, $MgFe_2O_4$, $Li_{0.5}Fe_{2.5}O_4$, Mn-Zn type ferrite, Ni-Zn type ferrite, Ni-Cu type ferrite, Cu-Zn type ferrite, Mg-Zn type ferrite, Li-Zn type ferrite, Zn type ferrite, and Mn type ferrite. These soft magnetic oxide powders may be used individually or as a combination of two or more.

The soft magnetic metal powder includes Fe-Si alloys, Fe-Al alloys (e.g., Alperm, Alfenol and Alfer), Permalloy (e.g., Ni-Fe binary alloys or multinary alloys with Mo, Cu, Cr, or another metal), Sendust (Fe 9.6 wt% Si 5.4 wt% Al), and Fe-Co alloys. These soft magnetic metal powders may be used either individually or as a combination of two or more.

[0067]
The soft magnetic oxide powder usually has a coercive force of 8 to 12,000 A/m and a saturation magnetization of 30 to 90 Am^2/kg. The soft magnetic metal powder usually has a coercive force of 1.6 to 8000 A/m and a saturation magnetization of 5 to 500 Am^2/kg.

[0068]
Although there are no particular limits on the shape of the soft magnetic powder, examples are a spherical shape, a tabular shape, and an acicular shape, and the size of the particles is preferably 5 to 800 nm.

[0069]
As necessary, the above magnetic powder can contain rare earth elements or transition metal elements similarly to the ferromagnetic powder contained in the magnetic layer 4, and further, a surface treatment similar to the surface treatment given to the ferromagnetic metal powder may be performed.

[0070]
Next, the nonmagnetic powder is explained. Examples of the nonmagnetic powder are a powder of nonmagnetic iron oxide (red oxide), barium sulfate, zinc sulfide, magnesium carbonate, calcium carbonate, calcium oxide, zinc oxide, magnesium oxide, magnesium dioxide, tungsten disulfide, molybdenum disulfide, boron nitride, tin dioxide, silicon carbide, cerium oxide, corundum, artificial diamond, garnet, siliceous stone, silicon nitride, molybdenum carbide, boron carbide, tungsten carbide, titanium carbide, diatomaceous earth, dolomite, and resins. Of these, nonmagnetic iron oxide (red oxide), titanium oxide, and boron nitride are preferably used. These nonmagnetic powders can be used either individually or as a combination of two or more. The shape of the nonmagnetic particles may be any of a spherical shape, a tabular shape, an acicular shape, or an amorphous shape. As for size, spherical, tabular, and amorphous particles preferably have a particle diameter of 5 to 200 nm, and acicular particles preferably have a major axis length of 20 to 300 nm with an acicular ratio of 3 to 20. When the nonmagnetic powder is used in combination with the magnetic powder (i.e., when the intermediate layer 3 is a magnetic layer), it is preferably used in an amount of 30 to 70 parts by weight and more preferably 40 to 60 parts by weight per 100 parts by weight of the magnetic powder. On the other hand, when the magnetic powder is not used (i.e., when the intermediate layer 3 is a nonmagnetic layer), the amounts of the other components are decided based on 100 parts by weight of the nonmagnetic powder. If necessary, the above various nonmagnetic powders can be subjected to the same surface treatment as is performed for the magnetic powder.

[0071]
The intermediate layer 3, whether magnetic or nonmagnetic, can contain a binder in addition to the above components and may further contain abrasive particles, lubricants, carbon black, hardeners, and similar substances. Although these components are not described specifically, they are similar to those used for the backcoating layer 5 and magnetic layer 4. Preferred amounts of these components are shown below, given in terms of parts by weight per 100 parts by weight of the total amount of the magnetic powder and the nonmagnetic powder (where the intermediate layer 3 is a magnetic layer) or 100 parts by weight of the nonmagnetic powder (where the intermediate layer 3 is a nonmagnetic layer).

- Binder: 8 to 40 parts by weight, particularly 10 to 25 parts by weight
- Abrasive particles: 1 to 30 parts by weight, particularly 1 to 12 parts by weight
- Lubricant: 0.5 to 20 parts by weight; particularly 1 to 7 parts by weight
- Carbon black: 0.5 to 30 parts by weight, particularly 2 to 10 parts by weight
- Hardener: 0.5 to 12 parts, particularly 2 to 8 parts by weight

As necessary, the intermediate layer 3 can contain various substances similar to the additives added to the magnetic layer 4.

[0072]
The intermediate layer 3 is formed by applying an intermediate layer coating composition containing the above various components and a solvent to the base 2. The solvent used is similar to those added to the backcoating composition and the magnetic coating composition. The amount of the solvent to be used is preferably 100 to 700 parts by weight and particularly preferably 300 to 500 parts by weight per 100 parts by weight of the total of the magnetic powder and the nonmagnetic powder (when the intermediate layer 3 is a magnetic layer) or 100 parts by weight of the nonmagnetic powder (when the intermediate layer 3 is a nonmagnetic layer).

[0073]
The thickness of the intermediate layer 3 must have some thickness from the standpoint of controlling the holding capacity of the lubricant, which is affects the durability of the magnetic tape 1, but too great a thickness results in the ready occurrence of cracking during deformation, so a thickness of 0.5 to 10 μm and particularly 0.1 to 3 μm is preferable.

[0074]
When the intermediate layer 3 is a layer having magnetism, the coercive force thereof preferably is within 80 to 350 kA/m and particularly 150 to 300 kA/m from the standpoints of overwrite characteristics and low- and high-range output balance. The saturation flux density thereof is preferably 0.02 to 0.1 T and particularly 0.03 to 0.09 T because overwrite characteristics decay and noise levels increase when it is too high and output is inadequate when it is too low.

[0075]
Materials constituting the base 2 are nonmagnetic materials including polymer resins such as polyesters such as polyethylene terephthalate, polybutylene terephthalate, polyethylene naphthalate, polycyclohexylene dimethylene terephthalate, and polyethylene bisphenoxycarboxylate; polyolefins such as polyethylene and polypropylene; cellulose derivatives, such as cellulose acetate butyrate and cellulose acetate propionate; vinyl resins such as polyvinyl chloride and polyvinylidene chloride; polyamide; polyimide; polycarbonate; polysulfone; polyether ether ketone; and polyurethane. These materials can be used individually or in combination of two or more. If necessary, the base made of these materials can be subjected to uniaxial or biaxial stretching, a corona discharge treatment, an adhesion-improving treatment, or the like.

[0076]
There are no particular limits on the thickness of the base 2, which is preferably 2 to 100 μm, and particularly 2 to 76 μm.

[0077]
Next, the outline of a preferred method for manufacturing the magnetic tape 1 shown in Fig. 1 is described.
First, a magnetic coating composition for forming the magnetic layer 4 and an intermediate layer coating composition for forming the intermediate layer 3 are applied simultaneously to the base 2 with a wet-on-wet system so that each layer is of a specified thickness in order to form coating layers of the magnetic layer 4 and the intermediate layer 3. In other words, the magnetic layer 4 is preferably coated and formed while the intermediate layer 3 is wet.

Then, the coating layers are subjected to magnetic field orientation, dried, and wound. Thereafter, the coated material is calendered, and the backcoating layer 5 is formed. Alternatively, the intermediate layer 3 and the magnetic layer 4 may be formed after the backcoating layer 5 is formed. The coated material is aged at 40 to 80°C for 6 to 100 hours and then slit to a prescribed width to obtain the magnetic tape. After slitting, the discoloration pattern 10 is formed on the backcoating layer 5 using the above method.

[0078]
The superimposing coating technique in the wet-on-wet system is described on column 42, line 31 to column 43, line 31 of Japanese Unexamined Patent Application Publication H5-73883—it is a method in which a magnetic coating composition is applied before an intermediate layer coating composition dries. With this method, magnetic tape that causes few dropouts, is compatible with high-density recording, and has coating layers of excellent durability is obtained.

[0079]
The magnetic field orientation treatment is carried out before each coating composition dries and is executed with a method that applies a magnetic field of about 40 kA/m or higher, preferably about 80 to 800 kA/m, in parallel with the surface coated with the magnetic coating composition or method that passes [the coated material] through a solenoid type magnet of about 80 to 800 kA/m while the magnetic coating composition is wet. By performing the magnetic field orientation treatment under such conditions, the ferromagnetic powder in the magnetic layer 4 can be orientated in the lengthwise direction of the magnetic tape 1. So that the thus orientated ferromagnetic powder does not change its orientation during drying following magnetic field orientation, warm air of 30 to 50°C is preferably blown from above the magnetic layer 4 immediately before the magnetic field orientation to bring about preliminary drying and control the amount of solvent remaining in the layers.

[0080]
Drying treatment is carried out by, for example, supplying a gas heated to 30 to 120°C, and at this time, the extent of the drying of the coated layers can be controlled by adjusting the temperature and the supply rate of the gas.

[0081]
The calendering can be performed by supercalendering or a similar method in which [the coated film] is passed between two rolls, such as a combination of a metal roll and a cotton roll or a synthetic resin roll, or two metal rolls. The calendering conditions are preferably, for example, 60 to 140°C and 100 to 500 kg/cm in linear pressure.

[0082]
In the manufacture of the magnetic tape 1, the surface of the magnetic layer 4 can be subjected to a finishing step, such as burnishing or cleaning, as necessary. The magnetic coating composition and the intermediate layer coating composition can also be applied with a generally known successive coating technique.

[0083]
Although the magnetic tape of the invention has been described based on the preferred embodiments thereof, the invention is not limited to the embodiments, and various modifications can be made within a range that does not depart from the spirit of the invention.

For example, in the above embodiment, a combination can alternatively be used of a single or plurality of discoloration pattern or patterns 10 comprising a continuous line with a specific width along the lengthwise direction of the magnetic tape 1 and a discoloration pattern or patterns 10 comprising discontinuous lines with a specified width along the lengthwise direction of the magnetic tape 1.

In addition, a straight or curved dotted line or a combination of the two could also be used as the discoloration pattern 10.

In addition, a circle, oval, or other shape, or a desired combination could also be used as the discoloration pattern 10.

Moreover, the magnetic tape 1 shown in Fig. 1 may have a primer layer between the base 2 and the intermediate layer 3 or the backcoating layer 5.

Furthermore, while the above embodiments are coated magnetic tapes, equivalent effects would come through the use of a metal-vapor-deposition-type magnetic tape instead.

[0084]
Working Examples
Below, the magnetic tape of the invention will be discussed in greater detail and the efficacy thereof will be validated through working examples. However, the invention is not limited to the working examples. In the working examples, the viscosity of the backcoating composition (viscosity as determined with an E-type viscosity meter at 100 rpm) is based on Working Example 1, and the viscosity of the backcoating compositions of the other working examples and comparative examples were adjusted by appropriately increasing or decreasing the amount of solvent (a 3:2:1 mixture by weight of methyl ethyl ketone, toluene, and cyclohexanone) so that the viscosity would be plus or minus 30% of the viscosity of the backcoating composition of Working Example 1. Unless otherwise specified, all the parts and percents are parts by weight and percentages by weight, respectively.

[0085]

Working Example 1

The following components (except the hardener) were individually kneaded in a kneader, dispersed in a stirrer, further finely dispersed in a sand mill, and filtered through a 1-μm filter, and then the hardener was added to prepare a backcoating composition, a magnetic coating composition, and an intermediate layer coating composition having the formulations described below.

[0086]

Formulation of Backcoating Composition

FeO_x 70 parts

(primary particle diameter: 32 nm, BET specific surface area: 52 m^2/g, coercive force: 10.3 kA/m (129 Oe); saturation magnetization: 85 Am^2/kg; divalent Fe: 19.7%; x = 1.363)

Phosphate ester (lubricant) 2 parts

(Phosphanol RE610 (product name) by Toho Chemical)

Carbon black 1 part

(primary particle diameter 54 nm, BET specific surface area: 32 m^2/g, DBP oil absorbance: 180 $cm^3/100$ g)

Indium-doped tin oxide (ITO) 30 parts

(primary particle diameter: 35 nm)

Polyurethane resin (binder) 17 parts

(number average molecular weight: 25,000; sulfoxyl group content: 1.2 x 10^{-4} M/g; glass transition point: 45°C)

Stearic acid (lubricant) 1 part

Polyisocyanate (hardener) 4 parts

(Coronate L (product name) by Nippon Polyurethane Industry Co., Ltd.); solid content: 75%

Methyl ethyl ketone (solvent) 90 parts

Toluene (solvent)	60 parts
Cyclohexanone (toluene)	30 parts

[0087]

Formulation of Magnetic Coating Composition

Acicular ferromagnetic powder containing primarily iron 100 parts
(Fe:Co:Al:Y:Ba ratio: 70:25:2:2:1 (by weight)) (major axis length: 0.07 μm; axis ratio: 6; coercive force: 160 kA/m (2010 Oe); saturation magnetization: 142 Am^2/kg; specific surface area: 56 m^2/g; X-ray particle diameter: 0.014 μm)

Alumina (abrasive; primary particle diameter: 0.15 μm) 8 parts

Carbon black 0.5 parts
(electrostatic preventing agent; primary particle diameter: 0.018 μm)

[Poly]vinyl chloride copolymer (binder) 10 parts
(mean degree of polymerization: 280; epoxy group content: 1.2% by weight; sulfoxyl group content: 8×10^{-5} equiv./g)

Polyurethane resin (binder) 7 parts
(number average molecular weight: 25,000; sulfoxyl group content: 1.2×10^{-4} equiv./g; glass transition point: 45°C)

Stearic acid (lubricant) 1.5 parts

2-ethylhexyl oleate (lubricant) 2 parts

Polyisocyanate (hardener) 5 parts
(Coronate L (product name) by Nippon Polyurethane Industry Co., Ltd.)

Methyl ethyl ketone 120 parts

Toluene 80 parts

Cyclohexanone 40 parts

[0088]

Formulation of Intermediate Layer Coating Composition

α-Fe_2O_3 100 parts
(mean particle diameter (major axis length): 0.12 μm, axis ratio: 10; specific surface area: 48 m^2/g)

Alumina (abrasive; primary particle diameter: 0.15 μm)	3 parts
Vinyl chloride copolymer (binder)	12 parts
(average degree of polymerization: 280; epoxy group content: 1.2 wt %; sulfoxyl group content: 8×10^{-5} equiv./g)	
Polyurethane resin (binder)	8 parts
(number average molecular weight: 25,000; sulfoxyl group content: 1.2×10^{-4} equiv./g; glass transition point: 45°C)	
Stearic acid (lubricant)	1 part
2-ethylhexyl oleate (lubricant)	4 parts
Polyisocyanate (hardener)	4 parts
(Coronate L (product name) produced by Nippon Polyurethane Industry Co., Ltd.)	
Methyl ethyl ketone	90 parts
Toluene	60 parts
Cyclohexanone	30 parts

[0089]
The intermediate layer coating composition and the magnetic coating composition were applied simultaneously on a the base comprising a 6-μm thick polyethylene naphthalate film by means of a die coater so that the dry thicknesses of the intermediate layer and the magnetic layer were 1.5 μm and 0.2 μm, respectively. Next, the coated films were passed through a solenoid type magnet of 400 kA/m while wet to perform magnetic orientation. Moreover, [they] were dried in a drying oven by blowing hot air of 80°C at a rate of 10 m/min. After the drying, the coated film was calendered to form an intermediate layer and a magnetic layer. Subsequently, the reverse side of the base was coated with the backcoating composition and dried at 90°C to form a backcoating layer having a thickness of 0.5 μm. The resulting magnetic tape stock was slit tape with a width of 12.7 mm. The coercive force of the magnetic layer in the obtained magnetic tape was 165 kA/m, the saturation magnetic flux density was 0.37 T, the angle ratio was 0.86, the arithmetic average roughness Ra was 4.2 nm, and the 10 point average roughness Rz was 38 nm.

[0090]
Next, as shown in Fig. 2, a plurality of discoloration patterns was formed on the backcoating layer by shining a laser beam at the backcoating layer of the resulting magnetic tape. The formation conditions of the discoloration patterns were as follows: the laser beam wavelength was 1.03 μm, the output was 0.3 W and the beam diameter was 18 μm. The discoloration patterns thus formed were linear, parallel to the lengthwise direction of the magnetic tape, and continuous, and they were formed with equal spacing across the widthwise direction of the magnetic tape.

[0091]

Working Example 2

The magnetic tape was obtained similarly to Working Example 1, and the discoloration patterns were formed similarly to Working Example 1 on the backcoating layer of the magnetic tape except that carbon black with a primary particle diameter of 28 nm, a BET specific surface area of 70 m^2/g, and a DBP oil absorbance of 50 $cm^3/100$ g was used as the carbon black in the backcoating composition used in Working Example 1.

[0092]

Working Example 3

The magnetic tape was obtained similarly to Working Example 1, and the discoloration patterns were formed similarly to Working Example 1 on the backcoating layer of the magnetic tape except that the FeO_x in the backcoating composition used in Working Example 1 was added at 100 parts and ITO was not added.

[0093]

Working Example 4

The magnetic tape was obtained similarly to Working Example 1, and the discoloration patterns were formed similarly to Working Example 1 on the backcoating layer of the magnetic tape except that in place of the ITO in the backcoating composition used in Working Example 1, Mn-Zn ferrite (primary particle diameter: 32 nm; BET specific surface area: 45 m^2/g; Fe_2O_3: MnO:ZnO = 70:21:10) was used.

[0094]

Working Example 5

The magnetic tape was obtained similarly to Working Example 1, and the discoloration patterns were formed similarly to Working Example 1 on the backcoating layer of the magnetic tape except that in place of the carbon black in the backcoating composition used in Working Example 1, silicone resin particles (alkyl-modified silicone resin particles; primary particle diameter: 300 nm;) were used at 0.5 parts.

[0095]
Comparative Example 1
The magnetic tape was obtained similarly to Working Example 1, and the discoloration patterns were formed similarly to Working Example 1 on the backcoating layer of the magnetic tape except that in place of the FeO_x in the backcoating composition used in Working Example 1, α-Fe_2O_3 (mean particle diameter (major axis length): 0.12 μm; axis ratio: 10; specific surface area: 48 m^2/g) was used.

[0096]
Comparative Example 2
The magnetic tape was obtained similarly to Working Example 1, and the discoloration patterns were formed similarly to Working Example 1 on the backcoating layer of the magnetic tape except that in place of the 70 parts of FeO_x in the backcoating composition used in Working Example 1, 10 parts of carbon black with a primary particle diameter of 28 nm, a BET specific surface area of 70 m^2/g, and a DBP oil absorbance of 50 $cm^3/100$ g were used.

[0097]
Comparative Example 3
The magnetic tape was obtained similarly to Working Example 1, and the discoloration patterns were formed similarly to Working Example 1 on the backcoating layer of the magnetic tape except that 50 parts of the polyurethane resin in the backcoating composition used in Working Example 1 were added.

[0098]
Comparative Example 4
The magnetic tape was obtained similarly to Working Example 1, and the discoloration patterns were formed similarly to Working Example 1 on the backcoating layer of the magnetic tape except that 10 parts of the polyurethane resin in the backcoating composition used in Working Example 1 were added.

[0099]
To evaluate the performance of the magnetic tapes obtained in the working and comparative examples, the reproduction output of the magnetic tape and the arithmetic mean roughness Ra, 10 point mean roughness Rz, coefficient of dynamic friction, electrical surface resistivity, hole diameter, and hole rate of the backcoating layer, and the light transparency and presence of discoloration of the backcoating layer were measure, while a servo signal writing test was performed. The results are shown in Table 1. Table 1 also lists the P:B ratio of the backcoating layer. Of these measurements, the measurements of the arithmetic mean roughness Ra, 10 point mean roughness Rz, hole diameter, and hole rate of the backcoating layer were taken in accordance with the above-described methods, and the other measurements were taken with the following methods:

[0100]
Reproduction Output
Signals having a recording wavelength of 0.6 μm were recorded in using a head tester method. The reproduction output was measured and expressed relatively taking Comparative Example 1 as a standard (0 dB).

[0101]
Coefficient of Friction (μ)
Using a TBT-300D tape tester by Yokohama System Research Institute, each magnetic tape was run at a tape speed of 3.36 cm/s with the surface of the magnetic layer thereof in 180° contact with a cylinder having a 5-mm diameter. The winding and unwinding tension levels were measured, and the coefficient of friction (μ) was determined with the following equation (iii):

[0102]
Equation 3

$$M = (1 / \pi)\ ln\ (\text{unwinding tension}) / (\text{winding tension}) \qquad \text{(iii)}$$

[0103]
Electrical Surface Resistivity
With two electrodes having a radius of 10 mm, plated with 24 K gold, and finished to have a roughness of N4 (ISO 1302), the electrodes were horizontally placed in parallel on the magnetic layer so that the center-to-center distance d would be 12.7 mm. A direct current voltage of 100±10 V was applied to the electrodes while imposing a force of 0.25 N to both ends of the magnetic tape. The current between the electrodes was measured. The electrical surface resistivity was obtained from this value.

[0104]
Light Transparency

Monochrome light with a wavelength of 900 nm was illuminated, and the ratio (percentage) of transmitted light to the incident light was determined and used as the light transparency. The values shown in Fig. 1 are measurements before laser illumination.

[0105]

Presence of Discoloration in Discoloration Pattern Portion

Any discoloration of the [discoloration pattern] portion exposed to laser light was observed with the naked eye and an optical microscope.

[0106]

Servo Tracking Test

Signals were recorded on the magnetic layer while servo tracking was performed with a push-pull method on the magnetic tapes for evaluation. The servo signals were detected by converting the difference in transparency of 1030-nm light between the discolored and non-discolored portions in the backcoating layer.

[0107]

Table 1

[See original for all numbers.]

		Output (dB)	Backcoating layer							Discoloration pattern		Servo tracking test
			Ra (nm)	Rz (nm)	Dynamic coefficient of friction	Electrical surface resistivity (ohms/[missing])	Hole diameter (nm)	Hole rate (%)	P:B ratio	Light transmission*1 (%)	Discoloration?	
Working examples											Yes	Passed
											Yes	Passed
											Yes	Passed
											Yes	Passed
											Yes	Passed
Comp. examples		0, standard				10^{11} or greater					No	Failed
											No	Failed
											No	Failed
											Yes	Failed*2

*1 Light transmission of medium before laser illumination.
*2 The test was impossible because large amounts of powder fell from the backcoating layer and the tape could not be properly run.

[0108]
As is apparent from the results in Table 1, it is seen that the magnetic tapes of the working examples (products according to the invention) enable reliable servo tracking without losing the original functionality of the backcoating layer as opposed to the tapes of the comparative examples. In particular, the magnetic tapes of the working examples were still capable of reliable servo tracking such as that shown in Table when 600 data tracks were recorded.

[0109]
Effects of the Invention
As described in detail, the invention provides magnetic tape that is capable of servo tracking without reducing the area of the data area.

The invention provides magnetic tape that is capable of servo tracking without losing the original functionality of the backcoating layer.

The invention provides magnetic tape with an improved track density.

The invention provides magnetic tape having a high recording capacity.

Brief Description of the Drawings

[Fig. 1]
A summary view showing the structure of a preferred embodiment of the magnetic tape of the invention.

[Fig. 2]
A schematic view illustrating a method for illuminating a light beam on the backcoating layer to form a discoloration pattern

[Fig. 3]
An expanded plan view of the essential parts of the backcoating layer following light-beam illumination.

[Fig. 4]
A schematic view illustrating a method for servo tracking using a push-pull system.

[Fig. 5]
A schematic view (corresponding to Fig. 3) illustrating another embodiment of the discoloration pattern.

Reference Symbols
1: magnetic tape
2: base

3: intermediate layer
4: magnetic layer
5: backcoating layer
10: discoloration pattern

Document name: Drawings

Fig. 1

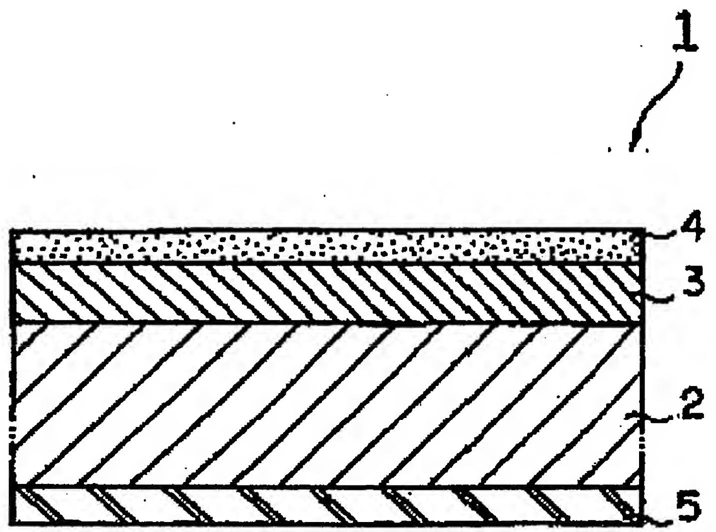


Fig. 2

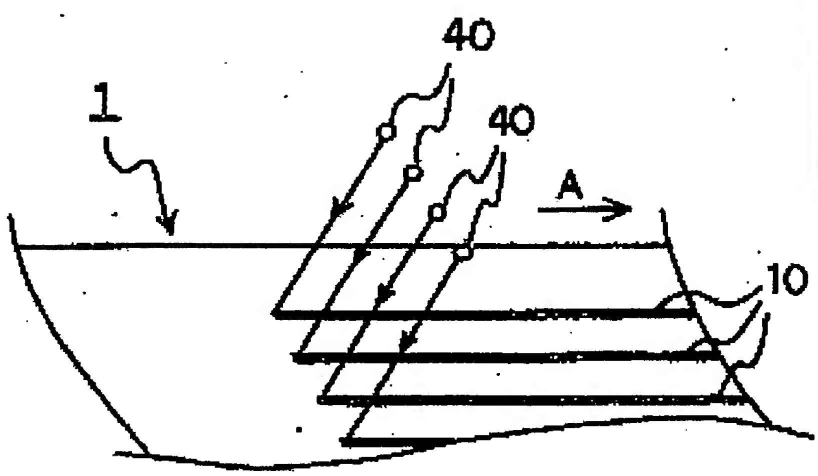


Fig. 3

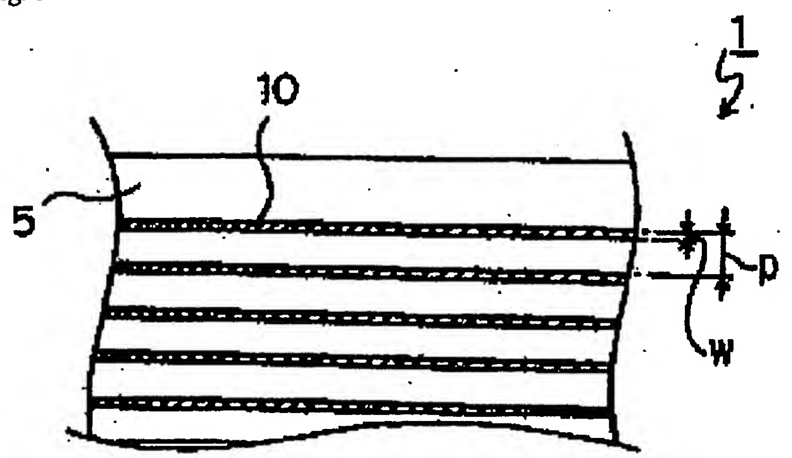
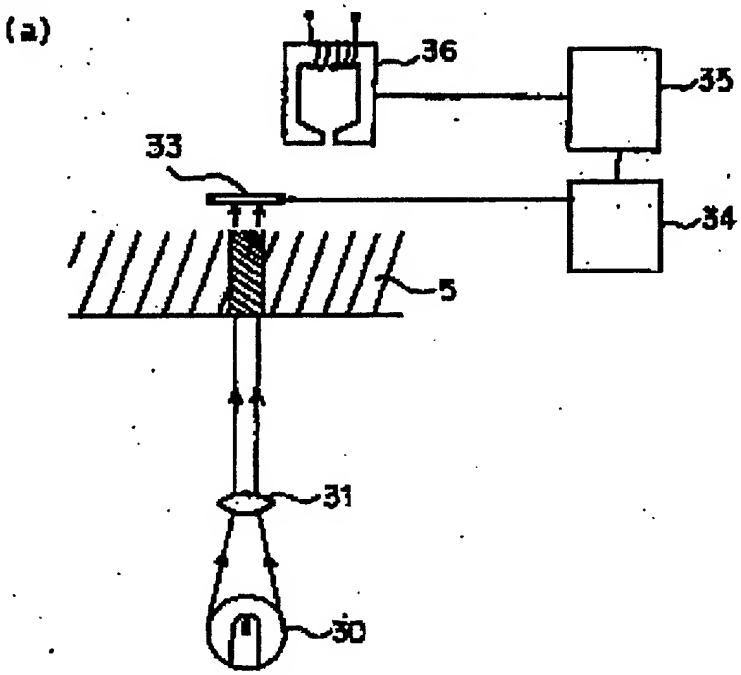


Fig. 4



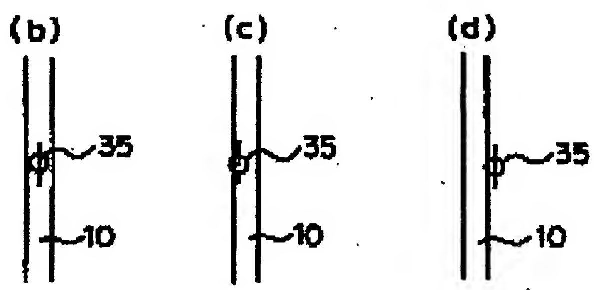
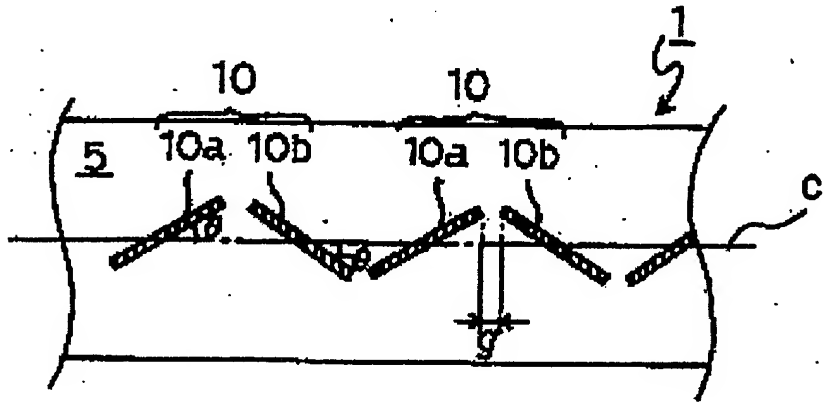


Fig. 5



Document name: Abstract

Abstract

Problem: To offer magnetic tape capable of servo tracking without reducing the area of the data area.

Means for solving the problem: Magnetic tape characterized in that microparticles irreversibly discolored due to an oxidation reaction are dispersed in a binder and a backcoating layer comprising minute holes of a number and size adequate for the provision of an adequate volume of oxygen for the oxidation reaction to occur are provided.

Selected drawing: Fig. 3

[Following page blank in original.]

Document name: Authority Correction Data
Document corrected: Patent application

Authorization information and additional information
Patent Applicant
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Name or title: Kao Corporation

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Name or title: Osamu Hatori

Appointed Agent
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Address or residence: Akasaka HKN Bldg., 6th Floor, 1-8-6 Akasaka, Minato-ku, Tokyo [Japan]
Name or title: Yoshiyuki Matsushima

[Following page blank in original.]

Document name: Applicant name change report
Date submitted: September 24, 1999
To: Takahiko Kondo, Director-General of Patent Office

Indication of Matter
Application Number: Heisei 9[4] Patent Application 289885

Recipient
Address or residence: 500 McCarthy Blvd., Milpitas, California 95035 USA
Name or title: Quantum Corporation
Representative: Jonathan Penn
Nationality: United States of America

Agent of Recipient
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Patent Agent
Name or title: Osamu Hatori

Agent of Recipient
Identification number: 100101292
Patent Agent
Name or title: Yoshiyuki Matsushima

Indication of fees
Register number of submittal: 013398
Fee paid: 4,600 yen

List of Items Submitted
Name of item: Transfer certificate 1
Indication of citation: Applicant name change report dated September 24, 1999 regarding Application Number: Heisei 9 Patent Application 288973
Name of item: Transfer certificate (translation) 1
Name of item: Power of attorney 1
Indication of citation: Applicant name change report dated September 24, 1999 regarding Application Number: Heisei 9 Patent Application 288973

[4] The Japanese imperial reign year corresponding to calendar 1997.

Name of item: Power of attorney (translation) 1

ASSIGNMENT

WHEREAS, Kao Corporation of 14-10, Nihonbashi Kayabacho 1-chome, Chuo-ku, Tokyo 103-8210, Japan ("Kao") owns the patent applications listed on the attached Schedule A, and has the full right to convey its entire right, title and interest, both legal and equitable, in and to said applications, free from all prior assignments, agreements, licenses, mortgages, security interests, or other encumbrances whatsoever; and,

WHEREAS, Quantum Corporation of 500 McCarthy Blvd., Milpitas, California, 95035, USA ("Quantum") is desirous of acquiring the entire right, title and interest in and to said applications;

WHEREAS, Kao and Quantum have entered into an SDLT Development Agreement dated on or about the date hereof (the "SDLT Agreement").

NOW, THEREFORE, pursuant and subject to the terms of the SDLT Agreement (including but not limited to Sections 6.1, 6.7 and 6.8 thereof) in consideration of 9,392,369 yen, Kao hereby assigns to Quantum, its successors and assigns, its entire right, title and interest throughout the world in the aforesaid applications, in any form or embodiment thereof, and in any applications filed in any foreign country based thereon, including the right to file foreign applications and claim priority under the provisions of any international convention or treaty. Kao makes no representation or warranty to Quantum, implied or otherwise, regarding the noninfringement of the inventions described in the aforesaid application or any other subject, except as expressly set forth herein.

KAO CORPORATION

By: Takuya Goto

Name: Takuya Goto

Title: President

Date: July 16, 1999

Schedule A

PATENT APPLICATIONS

Japanese Patent Applications:

9-288973
9-289885
9-290166
9-320197
9-320198
9-337733
10-14636
10-43924
10-153119
10-190067
10-215432
10-223416
10-297181

PCT Filings:

JP98/04766
JP98/04767
JP98/04765
JP98/05183
JP99/00667
JP99/00089

United States Patent Application:

09/176,722

Transfer Certificate

I,[5] Kao Corporation of 1-14-10 Nihonbashi Kayabacho, Chuo-ku, Tokyo 103-8210, Japan (hereinafter referred to as "Kao") am the owner of the patent applications listed on the attached Table A, and have the just right to transfer the entire right, title, and interest, both legal and equitable, in said that applications, free from all prior assignments, agreements, licenses, mortgages, security interests, or other encumbrances whatsoever; and

I, Quantum Corporation of 500 McCarthy Boulevard, Milpitas, California, 95035, USA (hereinafter referred to as "Quantum") which to acquire the entire right, title, and interest in said applications;

We, Kao and Quantum have entered into an SDLT Development Agreement dated around today to hereof (hereinafter referred to as the "SDLT Agreement"),

Therefore, pursuant to the terms of the SDLT Agreement (including but not limited to Sections 6.1,6.7, and 6.8 thereof) in consideration of 9,392,369 yen, Kao hereby assigns to Quantum, the assignee thereof, its entire right, title, and interest throughout the world in the aforesaid applications, in any form and embodiment thereof, and in any application filed in any foreign country based thereon, including the right to file foreign applications and claim priority under the provisions of any international convention or treaty. Kao makes no representation or warranty to Quantum, implied or otherwise, regarding the noninfringement of the inventions described in the aforesaid application or any other subject, except as expressly set forth herein.

KAO CORPORATION

(Signature of Takuya Goto)
President
July 16, 1999

[5] The parties are referred to as if they were persons (i.e., I, we).

Table A

Patent Applications

Japanese Patent Applications
- 9-288973
- 9-289885
- 9-290166
- 9-320197
- 9-320198
- 9-337733
- 10-14636
- 10-43924
- 10-153119
- 10-190867
- 10-215432
- 10-223416
- 10-297181

PCT Applications
- JP98/04766
- JP98/04767
- JP98/04765
- JP98/05183
- JP99/00667
- JP99/00689

United States Patent Application
- 09/176,722

POWER OF ATTORNEY

We hereby appoint ID No. 100078532 (patent attorney) Osamu Hatori and ID No. 100101232 (patent attorney) Yoshiyuki Matsushima to be our lawful attorneys and carry out any and all of the following acts, namely:

1. To take all the necessary procedures concerning Japanese Patent Application Nos. Heisei 9-288973, Heisei 9-289885, Heisei 9-320197, Heisei 9-320198, Heisei 10-14836, Heisei 10-43924, Heisei 10-153119, Heisei 10-190867, Heisei 10-215432, Heisei 10-229416, Heisei 10-237181, and Heisei 11-5141

2. To make or withdraw a priority claim based on the aforementioned applications in accordance with the provisions of Art. 41, para. 1 of the Patent Law or Art. 8, para. 1 of the Utility Model Law,

3. To change, abandon or withdraw the aforementioned applications,

4. To demand a trial against decision for final rejection of the aforementioned applications,

5. To demand an appeal trial against decision for dismissal of amendment of the aforementioned applications,

6. To take all the necessary procedures concerning a patent right, utility model right, design right, trademark right or right based on defensive mark registration deriving from the aforementioned applications or right with regard to the said rights or abandon the aforementioned rights,

7. To take all the necessary procedures concerning a statement of opposition to a patent or trademark (defensive mark) registration regarding the aforementioned applications,

8. To take all the necessary procedures concerning a demand for trial for invalidation of a patent, registration of an extension of the term of a patent right, design registration, trademark registration, defensive mark registration or renewal registration of period of duration of trademark (defensive mark) right regarding the aforementioned applications,

9. To demand a trial for correction regarding a patent right deriving from the aforementioned applications,

10. To take all the necessary procedures concerning a demand for trial for cancellation of a trademark registration regarding the aforementioned applications,

11. To withdraw a demand, request or motion concerning the aforementioned procedures specified in 1 to 10,

12. To take various procedures in accordance with the provisions of Administrative Complaints Examination Law with regard to the aforementioned in 1 to 11; and

13. To appoint or dismiss (a) sub-agent(s) to perform any and all acts specified in 1 to 12.

Address : 500 McCarthy Blvd., Milpitas, California, 95035, USA

Name : Quantum Corporation

Signature
Representative: Jonathan Roon
(Name) Jonathan Roon

(Title) Director of Intellectual Property
Deputy General Counsel

Date 7 September 1999

POWER OF ATTORNEY (Translation)

We hereby appoint ID No. 1000076532 (patent agent) Osamu Hatori and ID No. 100101292 (patent agent) Yoshiyuki Matsushima to be our attorneys and carry out any and all of the following acts:

1. To take all the necessary procedures concerning Japanese Patent Application Nos. H9-288973, H9-289885, H9-320197, H9-320198, H10-14636, H10-43924, H10-153119, H10-190867, H10-215432, H10-223416, H10-297181, and H11-5141,
2. To make and withdraw a priority claim based on the aforementioned applications in accordance with the provisions of Article 41, Paragraph 1 of the Patent Law or Article 8, Paragraph 1 of the Utility Model Law,
3. To change the application regarding the above applications or abandon or withdraw the application of the aforementioned applications,
4. To demand a trial against decision for final rejection of the aforementioned applications,
5. To demand a trial against decision for dismissal of amendment of the aforementioned applications,
6. To taken procedures concerning a patent right, utility model right, design right, trademark rights, or rights based on defensive mark registration deriving from the aforementioned applications or write with regard to the rights or abandoned the aforementioned rights,
7. To take procedures concerning a statement of opposition to a patent or trademark (defensive mark) registration regarding the aforementioned applications,
8. To take procedures concerning the demand for trial for invalidation of a patent, registration of an extension of the term of a patent right, design registration, trademark registration, defensive mark registration, or renewal registration of period of duration of trademark (defensive mark) right regarding the aforementioned applications,
9. To demand a trial for correction regarding a patent right deriving from the aforementioned applications,
10. To take procedures concerning a demand for trial for cancellation of a trademark registration regarding the aforementioned applications,
11. To withdraw a demand, request, or motion concerning the aforementioned procedures specified in the above items,
12. To take various procedures in accordance with the provisions of Administrative Complaints Examination Law with regard to the above items, and
13. To appoint or dismiss a sub-agent to perform any and all acts specified in the above items.

Address or residence: 500 McCarthy Blvd., Milpitas, California 95035 USA
Name or title: Quantum Corporation
Representative: (Signature of Jonathan Penn, Patent Dept. Manager)

September 7, 1999

Authorization and Additional Information

Application Number: Heisei 9[6] Patent Application 289885
File number: 19918000052
Document name: Applicant name change report
JPO coordinator: Yukishiro Okada 1717
Date prepared: November 15, 1999

Authorization and additional information

Names of submitted items:	Assignment Certificate (translation)	1
	Power of Attorney (translation)	1

No pages follow.

[Following page of original is blank.]

[6] The Japanese imperial reign year corresponding to calendar 1997.